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64 Water-absorbent resin having improved water-absorbency and improved water-dispersibility and process for producing same.

72 Water-absorbent resins having improved water-absorbency, water-absorption rate and water-dispersibility can be produced by crosslinking a water-absorbent resin comprising a carboxylate as a constituent of the resin with a crosslinking agent having at least two functional groups in the presence of water in a proportion of 0.01 to 1.3 parts by weight per part by weight of the resin in an inert solvent.

WATER-ABSORBENT RESIN HAVING IMPROVED
WATER-ABSORBENCY AND IMPROVED WATER-DISPERSIBILITY
AND PROCESS FOR PRODUCING SAME

1 This invention relates to a water-absorbent
having an improved dispersibility in water and an
improved water-absorbency, and a process for producing
the water absorbent resin. More particularly, it rela-
5 tes to a process for producing a water-absorbent resin
having an improved water-absorbency and an improved
water-dispersibility which comprises crosslinking a
water-absorbent resin comprising a carboxylate as a
constituent of the resin with a crosslinking agent
10 having at least two functional groups in the presence of
water in an inert solvent.

 Water absorbent resins are used in the field
of sanitation as menstrual articles, diaper, disposable
house-cloth and the like and in the field of agriculture
15 and horticulture as water retentive materials. Further,
they are useful in other various fields such as coagula-
tion of sludges, prevention of dew condensation on the
construction materials, dehydration of oils and so on.
As this type of water-absorbent resin, there are known
20 crosslinked carboxymethyl cellulose, partially cross-
linked polyethylene oxide, crosslinked hydrolyzate of
starch-acrylonitrile graft copolymer, partially cross-
linked polyacrylic acid salt and the like. However, all
of them have disadvantages that they have low water-

- 1 absorbency, and even if the water-absorbency is satisfactory, the water-dispersibility is inferior or the water-absorbing rate is low.

5 If these disadvantages are overcome, it is clear that the water absorbent resins will be more broadly used in various fields including sanitary articles such as sanitary napkin, paper diaper, underpat, and the like, and it has been desired that improved articles come into the market.

- 10 As the water-absorbent resin, there are known various synthetic resins as mentioned above. Particularly, Japanese Patent Application Kokai (Laid-Open) Nos; 93,716/81; 131,608/81 and 147,806/81 disclose methods for producing water-absorbent resins using as

15 the starting material acrylic acid, which are commercially easily available and are uniform in quality. These water-absorbent resins have an improved water-absorbency even in an aqueous electrolyte solution and an improved stability in the water-absorbed state.

- 20 However, these water-absorbent resins are still unsatisfactory in dispersibility in water and water-absorbing rate. Moreover, European Patent Application No. 80304099.7 (Publication No. 0036463) and U.S. Patent No. 4,340,706 disclose that a water-absorbent resin
- 25 suitable for usages requiring a stability in the fluid-absorbed state for a long period of time or a high water-absorbing rate can be obtained by crosslinking an

1 acrylic acid salt polymer with a crosslinking agent.
However, even the resin obtained by said method is still
not sufficient in water-dispersibility and water-
absorption rate.

5 The present inventors have further made
research on the conditions for crosslinking water-
absorbent resins with a crosslinking agent. As a
result, it has surprisingly and unexpectedly been found
that when a water-absorbent resin comprising a car-
10 boxylate as its constituent is crosslinked with a
crosslinking agent having at least two functional groups
in the presence of a specific amount of water in an
inert solvent, the water-dispersibility and the water-
absorption rate can both be greatly improved while
15 retaining its water-absorbency as it is.

According to this invention, there is provided
a process for producing a water-absorbent resin having
an improved water-absorbing rate and water-
dispersibility, characterized by crosslinking a water-
20 absorbent resin comprising a carboxylate as a consti-
tuent of the resin with a crosslinking agent having at
least two functional groups in the presence of water in
a proportion of 0.01 to 1.3 parts by weight per part by
weight of the resin in an inert solvent.

25 The water-absorbent resins used in this inven-
tion may be any polymer or copolymer comprising a car-
boxylate as its constituent. Among the polymers or

- 1 copolymers, there may preferably be used those comprising an alkali acrylate or an alkali methacrylate as their constituent and those comprising a carboxylate and a hydroxyl group as their constituents.
- 5 As said water-absorbent resin, there may be used crosslinked polyacrylic acid salts, crosslinked copolymers of acrylic acid salt and methacrylic acid salt, crosslinked saponification products of methylacrylate-vinylacetate copolymer crosslinked saponification products of starch-ethyl acrylate graft copolymer, crosslinked saponification products of starch-acrylic acid salt graft copolymer, crosslinked saponification products of starch-methyl methacrylate graft copolymer, crosslinked saponification products of starch-acrylamide graft copolymer, crosslinked saponification products of starch-acrylonitrile-2-acrylamide-2-methylpropane sulfonic acid graft copolymer, crosslinked saponification products of starch-acrylonitrile graft copolymer, crosslinked saponification products of starch-acrylonitrile-vinylsulfonic acid graft copolymer, polyethylene oxide crosslinked with acrylic acid, crosslinked sodium carboxymethyl cellulose and the like.
- 10
15
20

The water-absorbent resins comprising a carboxylate as its constituent can be produced by the methods disclosed in Japanese Patent Application Kokai (Laid-Open) Nos. 93,716/81; 131,608/81; and 147,806/81 as referred to above as well as the methods disclosed in

- 1 Japanese Patent Publication Nos. 30,710/79; 37,994/79;
and 46,200/78 and U.S.P. 4,041,228. Representative
methods for producing the water-absorbent resins which
may be used as the starting materials are as follows:

5 Method 1

- An aqueous solution of acrylic acid and alkali
acrylate is suspended in an alicyclic or aliphatic
hydrocarbon solvent containing a surfactant having an
HLB of 8 to 12 and polymerized in the presence of a
10 water-soluble radical polymerization initiator.

Method 2

- To the polymerization reaction product
obtained by the same way as in Method 1 is added a poly-
functional compound which can react with the carboxyl
15 group, for example, a water-soluble glycidyl ether com-
pound, a haloepoxy compound, or a dialdehyde compound,
and the resulting mixture is subjected to reaction,
after which the reaction product is slightly
crosslinked.

20 Method 3

- An aqueous solution of acrylic acid and alkali
acrylate is suspended in a mixed solvent of an alicyclic
or aliphatic hydrocarbon and an aliphatic alcohol con-
taining a surface active agent and then polymerized in
25 the presence of a water-soluble radical polymerization
catalyst.

1 Method 4

An aqueous solution of partially neutralized acrylic acid having a neutralization degree of 50 to 90% is suspended in an aliphatic ketone, and then polymerized in the presence of a water-soluble radical polymerization catalyst and a water-soluble high molecular weight dispersing agent.

Method 5

In a petroleum-based aliphatic hydrocarbon solvent is dispersed a more than 40% by weight aqueous alkali metal acrylate solution containing a water-soluble radical polymerization initiator in the presence of a sorbitan fatty acid ester having an HLB of 3 to 6 and the resulting suspension is subjected to polymerization in the absence of a crosslinking agent.

Method 6

An aqueous sodium acrylate polymer solution is mixed with a crosslinking agent which can react with the carboxylate, and the resulting mixture is heated and dried at 30°C or more to form a water-absorbent sodium acrylate polymer.

Method 7

Starch and acrylic acid are subjected to solution polymerization in the presence of ammonium ceric nitrate solution, after which aqueous sodium hydroxide and a crosslinking agent are added thereto. The resulting translucent solution is heated and dried to

1 form a water-absorbent resin.

Method 8

Vinyl acetate and methyl acrylate are subjected to emulsion polymerization, and the copolymer thus
5 obtained is saponified with sodium hydroxide in a methanol-water mixed solvent, after which the saponification product is removed by filtration and dried.

Other methods than those mentioned above may be used for producing the water-absorbent resins to be
10 used as the starting material in the process of this invention.

However, none of the resins produced by the above-mentioned methods exhibit sufficiently satisfactory water-dispersibility and water-absorption rate.

15 In this invention, in order to improve the performance of the above-mentioned conventional water-absorbent resins, the specific amount of water is allowed to be present in the water-absorbent resins. The effect of water, in this case, is greatly varied
20 depending upon its used amount. Accordingly, in this invention, water must be used in a proportion of 0.01 to 1.3 parts by weight per part of the water-absorbent resin. If the amount of water is less than 0.01 part by weight, the resin becomes in the substantially non-
25 swollen state and hence the reaction thereof with the crosslinking agent is difficult to proceed and requires a long period of time. Therefore, said amount is disad-

- 1 vantageous in industry. On the other hand, the amount
of water used is more than 1.3 parts by weight, the
resin becomes too much swollen, and hence, the
subsequent crosslinking reaction proceeds to the
5 interior of the resin particles, whereby the cross-
linking density in the surface layer of the polymer
particle becomes low, resulting in no improvement in
water-dispersibility and water-absorption rate. When
it is intended to enhance the water-dispersibility and
10 water-absorption rate in this case, more crosslinking
agent becomes required, which rather reduces extremely
the water-absorbency of the resin. Therefore, the use
of more than 1.3 parts by weight of water is not
desirable.
- 15 In view of the above fact, a particularly pre-
ferable result is obtained when water is used in a pro-
portion of 0.05 to 1.0 part by weight per part by weight
of the water-absorbent resin.

- The inert solvent used in this invention is a
20 solvent which does not affect the water-absorbent resin
at all, and includes, for example, lower alcohols, poly-
hydric alcohols, ketones, ethers, aliphatic hydrocar-
bons, aromatic hydrocarbons, alicyclic hydrocarbons,
halogenated hydrocarbons and the like. As the lower
25 alcohol, preferred are alcohols having 1 to 8 carbon
atoms, such as methyl alcohol, ethyl alcohol, normal
propyl alcohol, isopropyl alcohol, normal butyl alcohol,

1 isobutyl alcohol, tertiary butyl alcohol, amyl alcohol,
octyl alcohol and the like. As the polyhydric alcohol,
preferred are ethylene glycol, propylene glycol, gly-
cerine, diethylene glycol and the like, and as the
5 ether, there may be used diethyl ether, dibutyl ether,
dioxane, tetrahydrofuran and the like.

As the aliphatic hydrocarbon, there may be
used n-pentane, n-hexane, n-heptane, ligroin and the
like; as the aromatic hydrocarbon, there may be used
10 benzene, toluene, xylene, chlorobenzene and the like,
and as the alicyclic hydrocarbon, there may be used
cyclopentane, methylcyclopentane, cyclohexane,
methylcyclohexane, and the like. Further, the haloge-
nated hydrocarbon includes carbon tetrachloride, methy-
15 lene chloride, chloroform, ethylene dichloride, trich-
loroethylene and the like.

The above-mentioned inert solvents may be used
alone or in admixture of two or more. However, in
industry, the use of methyl alcohol, n-hexane, n-heptane
20 or cyclohexane alone is more preferable.

The proportion of the inert solvent to the
water-absorbent resin is preferably 0.1 to 50 parts by
weight, more preferably 0.2 to 20 parts by weight, per
part by weight of the water-absorbent resin, though it
25 may be varied depending upon the kind of water-absorbent
resin and the kind of the inert solvent. The smaller
the amount of the inert solvent, the higher the volume

1 efficiency. However, the dispersion of the water-
absorbent resin becomes bad and the uniform crosslinking
becomes difficult. On the contrary, when the amount of
the inert solvent is larger, the water-absorbent resin
5 tends to be dispersed and the crosslinking tends to take
place uniformly. However, the volume efficiency becomes
bad and the resin becomes difficult to handle. There-
fore, the process of this invention must be carried out
using water in an amount within the above-mentioned
10 range.

As the crosslinking agent used in this inven-
tion, there may be used any crosslinking agent having at
least two functional groups which can react with the
carboxylate, or groups present in the polymer such as
15 hydroxyl group, sulfone group, amino group and the like,
including diglycidyl ether compounds, haloeпоxy com-
pounds, aldehyde compounds, isocyanate compounds and the
like. among them, diglycidyl ether compounds are par-
ticularly preferred. Specific examples of the diglyci-
20 dyl ether compounds are (poly)ethyleneglycol diglycidyl
ether, (poly)propyleneglycol diglycidyl ether,
(poly)glycerine diglycidyl ether and the like, among
which ethylene glycol diglycidyl ether is most pre-
ferable. Examples of the haloeпоxy compounds are epich-
25 lorohydrin, epibromohydrin, α -methylepichlorohydrin and
the like, and examples of the aldehyde compounds are
glutaraldehyde, glyoxal and the like, and examples of

1 the isocyanate compounds are 2,4-tolylene diisocyanate,
hexamethylene diisocyanate and the like. All of them
may be used effectively in this invention. such
crosslinking agents are selected depending upon the kind
5 of the water-absorbent resin, and the purpose of use
thereof lies in imparting a crosslinked structure again
to the resin having water-absorbency. Therefore, the
amount of the crosslinking agent used is generally very
slight, and may be varied depending upon the kind of
10 crosslinking agent, the kind of inert solvent, the
amount of water present, and the purpose of use of
water-absorbent resin, though usually appropriate is the
amount of 0.005 to 5.0% by weight based on the weight of
the water-absorbent resin. In general, if the amount of
15 the crosslinking agent used is less than 0.005% by
weight, the effect of addition does not appear, and if
the amount is more than 5.0% by weight, there is
obtained a resin having an extremely high degree of
crosslinking which reduces remarkably the water-
20 absorbency. Therefore, such amounts are not desirable.

There may be used many methods for
crosslinking the resin with a crosslinking agent in this
invention. That is to say, the water-absorbent resin
may be dispersed in an inert solvent, followed by adding
25 water and then the crosslinking agent to the resulting
dispersion, and thereafter heat-treating the resulting
slurry, preferably under reflux, or alternatively, the

1 slurry after the addition of the crosslinking agent may
be heated and evaporated, to effect the crosslinking.
As other methods, the reaction mixture obtained by the
reaction in the presence of an inert solvent mentioned
5 above may be subjected to adjustment of the ratio between the water-absorbent resin and the water, followed by adding a crosslinking agent and thereafter, heat-treating the resulting mixture, preferably under reflux, or alternatively, the slurry after the addition of the
10 crosslinking agent may be heated and evaporated, to effect the crosslinking. The heat-treated product may be, of course, subjected to filtration and drying to obtain a commercial product.

In order to conduct the above-mentioned
15 crosslinking reaction smoothly, the temperature for the heat-treatment of the slurry may preferably be usually within the range of from 40° to 150°C though the temperature may be varied depending upon the kind of the crosslinking agent used, the kind of the inert solvent
20 used, the amount of water present and the purpose of use of the water-absorbent resin and hence cannot be uniquely determined.

This invention is characterized in that the treatment method is simple, the formation of unswollen
25 powder lump at the initial stage of water-absorption can be prevented, the dispersibility in water can greatly be improved and simultaneously the water-absorption rate is

- 1 much enhanced as well as the workability in actual use
in various fields can be improved.

This invention is further explained below in
more detail referring to Examples and Comparative
5 Examples. However, these Examples are merely by way of
illustration and not by way of limitation.

The term "absorbency" used herein means a
value determined according to the following procedure:
In the case of deionized water-absorbency, 2 liters of
10 deionized water and 1 g of the dried polymer were placed
in a 3-liter beaker, and water was absorbed by the
polymer for a predetermined period of time while the
mixture was allowed to stand, after which the polymer
was collected by filtration with a 100-mesh metallic
15 wire gauze and the volume of the swollen polymer
obtained as a filtered cake was measured by means of a
messcylinder. The value was taken as the deionized
water-absorbency.

In the case of saline solution-absorbency, 200
20 ml of saline solution (0.9% by weight aqueous sodium
chloride solution) and 1 g of dried polymer were placed
in a 300-ml beaker and the solution was absorbed by the
polymer for the predetermined period of time while the
mixture was allowed to stand, after which it was
25 filtered with a 200-mesh metallic wire gauze, and the
volume of the swollen polymer obtained as a filtered
cake was measured by means of a messcylinder. The value

1 was taken as the saline solution-absorbency.

Comparative Example 1

5 In a 200-ml flask was placed 39.1 g of acrylic acid having a purity of 99.8% by weight, and 76.5 g of a 22.6% by weight aqueous sodium hydroxide solution was dropped thereinto with cooling and stirring to neutralize 80 mole% of the acrylic acid, after which 0.13 g of potassium persulfate was added thereto. The resulting
10 mixture was stirred at room temperature to form a solution.

Into a 500-ml flask provided with a reflux condenser purged with nitrogen were charged 213 g of cyclohexane and 1.9 g of sorbitan monolaurate having an
15 HLB of 8.6, after which a surfactant was dissolved at room temperature with stirring. To the resulting solution was added dropwise the above-mentioned aqueous partially neutralized acrylic acid solution to form a suspension. The flask was again sufficiently purged
20 with nitrogen, the temperature of the suspension was elevated and polymerization was conducted for 3 hours while keeping the bath temperature at 55-60°C.

The resulting polymerization mixture was vaporized to dryness under reduced pressure, to obtain
25 48.0 g of fine, granular, dried polymer. The water-absorbency and saline solution-absorbency of the polymer were as shown in Table 3.

1 Comparative Example 2

In a 100-ml flask was placed 39.1 g of acrylic acid having a purity of 99.8% by weight, and 54.2 g of a 28% by weight aqueous sodium hydroxide solution was
5 dropped thereinto with cooling and stirring to neutralize 70 mole% of the acrylic acid, after which 0.13 g of potassium persulfate was added thereto. The resulting mixture was stirred to form a solution at room temperature.

10 In a 500-ml flask provided with a stirrer purged with nitrogen were placed 213.6 g of cyclohexane and 1.1 g of sorbitan monostearate, and the surfactant was dissolved at 50-55°C with stirring. The resulting solution was cooled to room temperature, and the above-
15 mentioned partially neutralized acrylic acid solution was dropped thereinto to form a suspension. The temperature of the suspension was elevated with stirring while keeping the system at a reduced pressure of 300 Torr, and the suspension was kept at 50°C to conduct the
20 polymerization for 6 hours, after which the refluxing was stopped and the reaction mixture was evaporated to dryness under reduced pressure, thereby obtaining 48.8 g of a fine powder of white dried polymer. The water-absorbency and saline solution-absorbency of the polymer
25 were as shown in Table 3.

1 Comparative Example 3

Into a reactor provided with a stirrer, a nitrogen-blowing tube and a thermometer were charged 20 g of corn starch and 400 g of water, and the resulting mixture was stirred at 80°C for one hour under a nitrogen atmosphere. The resulting aqueous solution was cooled to 30°C, and 60 g of acrylic acid and 30 g of ammonium ceric nitrate solution (0.1 mole of cerium ion in 1 N nitric acid) were added thereto, after which the resulting mixture was subjected to polymerization at 30-40°C for 3 hours.

To the polymerization mixture was added 50 g of a 30% by weight aqueous sodium hydroxide solution with stirring, and subsequently, 0.5 g of ethylene glycol diglycidyl ether was added thereto, after which the resulting mixture was poured into a tray, and dried at 100°C for 3 hours and then at 60°C for 2 hours under reduced pressure. The resulting sheet-shaped material was pulverized to obtain 95 g of white powder. The water-absorbency and saline solution-absorbency were as shown in Table 3.

Comparative Example 4

In 300 ml of water containing 3 g of polyvinyl alcohol and 10 g of sodium chloride were dispersed 60 g of vinyl acetate and 40 g of methyl acrylate, and 0.5 g of benzoyl peroxide was added thereto, after which the

- 1 resulting mixture was subjected to suspension polymeri-
zation at 65°C for 6 hours. The resulting copolymer was
separated by filtration and dried.
- 5 subsequently, 34.4 g of the copolymer thus
obtained was suspended in a saponifying solution con-
sisting of 800 g of methanol, 40 g of water and 160 ml
of 5 N aqueous sodium hydroxide solution, and the
resulting suspension was subjected to saponification at
25°C for one hour, after which the temperature of the
10 saponification product was elevated to continue the
saponification for 5 hours. After the completion of the
saponification, the saponification product was washed
well with methanol, and thereafter dried to obtain 26 g
of a water-absorbent copolymer. The water-absorbency
15 and saline solution-absorbency of the polymer were as
shown in Table 3.

Comparative Example 5

- The same procedure as in comparative Example 1
20 was repeated, except that the 39.1 g of acrylic acid
having a purity of 99.8% by weight was replaced by 35.2
g of acrylic acid having a purity of 99.8% by weight and
4.7 g of methacrylic acid having a purity of 99% by
weight, to obtain 49.3 g of finely granular, dried
25 polymer. The water-absorbency and saline solution-
absorbency of the polymer were as shown in Table 3.

1 Example 1

In a 500-ml flask provided with a stirrer, an oil bath and a cooler was placed 41 g of the water-absorbent resin having a water content of 2.5% obtained
5 in the same manner as in Comparative Example 1, and 50 g of methanol was then added thereto, after which a solution of 32 mg of ethylene glycol diglycidyl ether in 9 g of water (total amount of water: 10 g) was added thereto with stirring. The resulting mixture was well stirred
10 and then evaporated to dryness by keeping the oil bath at 110°C, to obtain 41.5 g of finely granular, dried polymer. The water-absorbency and saline solution-absorbency of the polymer were as shown in Table 3.

15 Examples 2-6

The same procedure as in Example 1 was repeated, except that the amounts of methanol and water were varied as shown in Table 1, to obtain finely granular, dried polymers. The water-absorbency and saline
20 solution-absorbency of the polymers were as shown in Table 3.

Example No.	Methanol (g)	Water (g)	Total water (g)
2	90	2.3	3.3
3	148	11.0	12.0
4	10.3	5.9	6.9
5	32	7.0	8.0
6	88	31.0	32.0

1 Example 7

The same procedure as in Example 1 was repeated, except that the methanol was replaced by n-heptane, to obtain finely granular, dried polymer.

- 5 The water-absorbency and saline solution-absorbency of the polymer were as shown in Table 3.

Examples 8-10

- 10 The same procedure as in Example 7 was repeated, except that the amount of ethylene glycol diglycidyl ether was varied as shown in Table 2, to obtain finely granular, dried polymer. The water-absorbency and saline solution-absorbency of the polymer were as shown in Table 3.

Table 2

Example No.	Ethyleneglycol diglycidyl ether (mg)
8	10
9	100
10	500

1 Example 11

The same procedure as in Example 1 was repeated, except that epichlorohydrin was substituted for the ethylene glycol diglycidyl ether, to obtain
 5 finely granular, dried polymer. The water-absorbency and saline solution-absorbency of the polymer were as shown in Table 3.

Example 12

10 From the polymerization mixture obtained in Comparative Example 2 was removed 22.2 g of the water and subsequently, 47.4 mg of ethylene glycol diglycidyl ether was added thereto, after which the resulting mixture was well stirred. The oil bath was thereafter kept
 15 at 110°C to evaporate the mixture to dryness, thereby obtaining finely divided, dried polymer. The water-absorbency and saline solution-absorbency of the polymer were as shown in Table 3.

1 Example 13

 The same procedure as in Example 1 was repeated, except that the water-absorbent resin obtained in the same manner as in Comparative Example 3 was substituted for the water-absorbent resin and polyethylene glycol diglycidyl ether was substituted for the ethylene glycol diglycidyl ether, to obtain powdery, dried polymer. The water-absorbency and saline solution-absorbency of the polymer were as shown in Table 3.

 Example 14

 The same procedure as in Example 1 was repeated, except that the water-absorbent resin obtained in the same manner as in Comparative Example 4 was substituted for the water-absorbent resin, and glycerine diglycidyl ether was substituted for the ethylene glycol diglycidyl ether, to obtain finely granular, dried polymer. The water-absorbency and saline solution-absorbency of the polymer were as shown in Table 3.

 Example 15

 The same procedure as in Example 1 was repeated, except that the water-absorbent resin obtained in the same manner as in Comparative Example 5 was substituted for the water-absorbent resin, to obtain finely granular, dried polymer. The water-absorbency

- 1 and saline solution-absorbency of the polymer were as
shown in Table 3.

Comparative Example 6

- 5 The same procedure as in Example 1 was
repeated, except that 100 g of n-heptane and 59 g of
water were substituted for the methanol, to obtain a
lump-like, dried polymer, which was then pulverized and
used to measure the water-absorbency and saline
10 solution-absorbency. The results obtained were as shown
in Table 3.

Table 3

	Amount of water present (% by weight)	Solvent	
		Kind	Amount (% by wt.)
Comp. Ex. 1	-	-	-
" " 2	-	-	-
" " 3	-	-	-
" " 4	-	-	-
" " 5	-	-	-
Example 1	10	Methanol	50
" 2	2.5	"	67.5
" 3	6.0	"	74
" 4	12	"	18
" 5	10	"	40
" 6	20	"	55
" 7	10	n-Heptane	50
" 8	10	"	50
" 9	10	"	50
" 10	10	"	50
" 11	10	Methanol	50
" 12	8.34	Cyclohexane	75.03
" 13	10	Methanol	50
" 14	10	"	50
" 15	10	"	50
Comp. Ex. 6	30	n-Heptane	50

Note: E-100: Ethylene glycol diglycidyl ether
 E-400: Polyethylene glycol diglycidyl ether
 ECH : Epichlorohydrin
 G-100: Glycerine diglycidyl ether

Table 3 (Cont'd)

Water-absorbent resin (% by wt.)	Water/resin weight ratio	Crosslinking agent		
		Kind	Amount (mg)	
-	-	-	-	
-	-	-	-	
-	-	-	-	
-	-	-	-	
-	-	-	-	
40	0.25	E-100	32	
30	0.083	"	"	
20	0.3	"	"	
70	0.17	"	"	
50	0.2	"	"	
25	0.8	"	"	
40	0.25	"	"	
40	0.25	"	10	
40	0.25	"	100	
40	0.25	"	500	
40	0.25	ECH	32	
16.63	0.50	E-100	47.4	
40	0.25	E-400	32	
40	0.25	E-100	32	
40	0.25	E-100	32	
20	1.50	E-100	32	

Table 3 (Cont'd)

Deionized water-absorbency (ml/g)			Saline solution-absorbency (ml/g)			
After 1 min	After 5 min	After 10 min	After 1 min	After 5 min	After 10 min	
17	44	132	2	5	11	
60	100	200	8	15	25	
100	150	180	9	25	30	
80	200	420	8	20	41	
150	230	520	10	24	31	
670	950	1250	55	80	110	
330	460	1100	31	65	98	
650	930	1270	57	73	104	
550	860	1180	56	75	105	
600	910	1230	57	84	101	
680	690	710	58	60	63	
640	920	1300	54	77	116	
320	640	950	32	63	90	
650	970	1230	60	81	105	
550	570	610	59	65	66	
640	900	1080	53	74	98	
480	520	540	51	55	56	
160	170	190	20	31	33	
300	410	670	18	41	50	
700	1050	1390	63	86	122	
70	170	230	6	18	24	

[illegible]

CLAIMS:

1. A process for producing a water-absorbent resin having an improved water-absorbency, characterized by crosslinking a water-absorbent resin comprising a carboxylate as a constituent of the resin with a crosslinking agent having at least two functional groups in the presence of water in a proportion of 0.01 to 1.3 parts by weight per part by weight of the resin in an inert solvent.
2. A process according to Claim 1, wherein the water-absorbent resin is a polymer comprising an alkali acrylate or methacrylate as a constituent.
3. A process according to Claim 1, wherein the water is present in a proportion of 0.05 to 1.0 parts by weight per part by weight of the water-absorbent resin.
4. A process according to Claim 1, wherein the water-absorbent resin comprises a carboxylate and a hydroxyl group as constituents of the resin.
5. A process according to Claim 1, wherein the inert solvent is used in a proportion of 0.2 to 20 parts by weight per part by weight of the water-absorbent resin.
6. A process according to Claim 1, wherein the inert solvent is methanol.
7. A process according to Claim 1, wherein the inert solvent is cyclohexane.
8. A process according to Claim 1, wherein the

inert solvent is n-heptane.

9. A process according to Claim 1, wherein the crosslinking agent is a diglycidyl ether compound.

10. A process according to Claim 9, wherein the
5 crosslinking agent is ethylene glycol diglycidyl ether.

11. A water-absorbent resin having an improved water-absorbency obtained by the process according to Claim 1.

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(54) Water-absorbent resin having improved water-absorbency and improved water-dispersibility and process for producing same.

(57) Water-absorbent resins having improved water-absorbency, water-absorption rate and water-dispersibility can be produced by crosslinking a water-absorbent resin comprising a carboxylate as a constituent of the resin with a crosslinking agent having at least two functional groups in the presence of water in a proportion of 0.01 to 1.3 parts by weight per part by weight of the resin in an inert solvent.

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EUROPEAN SEARCH REPORT

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Application number

EP 82 11 1579

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 7)
D, X	EP-A-0 036 463 (SEITETSU K.K.) * claims; examples * & JP - A - 56 131608 (SEITETSU) (Cat. D)	1-3, 5, 7, 9-11	C 08 L 33/02 A 61 L 15/00
X	US-A-3 926 891 (GROSS J.R. et al.) * claims; examples; column 2, lines 20-31; column 3, lines 6-14 *	1-6, 9-11	
X	US-A-3 980 663 (GROSS J.R.) * claims; examples; column 1, lines 56-61 * -----	1-6, 9-11	
			TECHNICAL FIELDS SEARCHED (Int. Cl. 7)
			A 61 L 15/00 C 08 L 33/02
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 14-02-1984	Examiner FOUQUIER J.P.
CATEGORY OF CITED DOCUMENTS		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document			